Comparison between methods of estimating historical and future recruitment for the west coast rock lobster super-areas

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WARNING: The results and conclusions in this document are PRELIMINARY; the calculations will need to be repeated using updated estimates of historical poaching levels, and hence may change.

Summary

This document introduces a new approach for estimating historical recruitment, and consequently projecting future recruitment, for west coast rock lobster, which takes account of the recommendations of International Panel at the 2018 stock assessment workshop (IWS). The results are compared to those from the previous approach for each super-area. Results of the new approach are sensitive to the weighting given to the residuals about an average over time in the new method, and a proposal for a common choice to address this is made.

Introduction

Following the IWS in December 2018 some new methods for estimating historical west coast rock lobster recruitments, and from those the recruitments for projections based on the stock assessments were suggested. The IWS report reads:

"The projections used to select WCRL TACs consistent with avoiding further decline were implemented by projecting poaching at current levels and the central tendency of recent recruitment (given by the geometric mean) forward through to 2025. These projections could be improved in several ways: (a) bias-correct the geometric mean assuming log-normality, (b) use an arithmetic mean recruitment, (c) use bootstrap samples of the empirical distribution of recruitment values in the projections, or (d) preferably by re-parameterizing the 1975-2017 recruitment parameters via an estimated mean level ($\overline{R}$) multiplied by annual recruitment deviates. This last parameterization would enable projections via randomly selecting recruitment values from their estimated distribution. Even so, further potential declines are predicted without a substantial reduction in both catch and poaching."

It is suggestion (d) that is pursued below, after first summarising the approach used last year. Results are shown for historical estimates of recruitment, and for the associated fits to the abundance indices for each super-area. These are then used in providing future projections for biomass (B75m). The new (2019) results, which incorporate data for a further year in fitting the population model, are compared to those from the previous (2018) approach.

The 2018 assessment method:

Estimation and projection of recruitment

Recruitment is modelled as for previous assessments and projections. Historically recruitment is assumed to have changed linearly between a set of estimated recruitment values over time. Thus, past recruitments are estimated for each super-area for the years indicated by the following list of parameters:

- R1910, R1920, R1950, R1970, R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004, R2007 and R2010, where furthermore

- the R2007 and 2010 values are constrained by a penalty added to the –*ln*L based on the geometric mean as follows:

$$pen1 = \frac{1}{2}\frac{(lnR_{2007} - ln\bar{R})^2}{\sigma_R^2} \quad \text{and}$$

$$pen2 = \frac{1}{2}\frac{(lnR_{2010} - ln\bar{R})^2}{\sigma_R^2} \quad \text{where}$$

$$\sigma_R^2 = \frac{\sum_{y=1975}^{y=2010}(lnR_y - ln\bar{R})^2}{9}$$

and finally

- all recruitments are constrained to be less than R1910.

Then for the (deterministic) projections as reported last year:

- R2013+ values are set equal to the **geometric mean ($\bar{R}$)** of the R1975, R1980, R1985, R1990, R1995, R1998, R2001, R2004, R2007 and R2010 estimated values for the super-area in question.

This projection approach has a number of problems (some as identified by the IWS).

- Being deterministic, rather than based on stochastic sampling from past recruitments as in earlier analyses for OMPs, it needed to have used the mean rather than the median of these past recruitments to better reflect average past resource productivity into the future.
- The R2007 and R2010 values were not dealt with appropriately in the estimation.
- In estimating a median (or average), account needed to be taken of the lesser precision of the more recent estimates of recruitment.

The new 2019 assessment method:

Note that what follow are intermediate results, having been updated to take account of the most recent abundance index and other data that are used in the fitting process, as well as incorporate interim revised poaching time series.

The 2018 method estimates:

R_{1910}, x_{1920}, x_{1950}, x_{1970}, x_{1975}, x_{1980}, x_{1985}, x_{1990}, x_{1995}, x_{1998}, x_{2001}, x_{2004}, x_{2007} and x_{2010},

where $x_y = \frac{R_y}{R_{1910}}$. [14 estimable parameters]

NOW for the new 2019 method

Estimate $R_{1910,}\, x_{1920}, x_{1950}$ [3 estimable parameters]

Estimate $\bar{x} = \sum_{y=1970}^{y=2010}(x_y)\,/11$ [1 estimable parameter]

Estimate for *y*=1970…2010: $x_y = \bar{x}e^{\varepsilon_y - \sigma_R^2/2}$ [11 estimable ε_y parameters]

Add to the –lnL a penalty which is

$$\frac{1}{2\sigma_R^2}\sum_{y=1970}^{y=2010}\varepsilon_y^2$$

Note that estimating $\bar{x}$ directly in this way takes account of the different precisions with which the individual recruitment values are estimated.

For the new deterministic projections reported below, R2013+ values are set equal to $\bar{x}$. Furthermore (Johnston and Butterworth, 2018):

- Future poaching is assumed as per the new interim poaching scenario (currently under discussion in the poaching TT)
- Future commercial catches for the 2019+ seasons are as follows (as per the 2-step recommendation):
  A12: 6 MT
  A34: 29 MT
  A56: 19 MT
  A7: 29 MT
  A8+: 161 MT

Note that for A7 the initial model fits to the Trap CPUE data were very poor. As in previous assessments for A7, this issue has been addressed by increasing the weight of the 2009-2018 Trap CPUE data in the likelihood by a factor of 10, which in particular provides a much improved reflection of the recent downward trend in trap CPUE for that super-area.

Results

Results for the 2018 assessment and for the new 2019 assessment approach are given in Tables 1a-e. The 2019 results use the most recent data available, as indicated above (whilst the 2018 results are as reported at the 2018 IWS, and therefore are not making use of the data now available for the most recent year).

Figures 1a-e compare recruitment estimates, Figures 2a-e compare fits to abundance indices and Figures 3a-e compare deterministic projections. The 2019 method is applied both for the value of σ_R estimated from the fit for the super-area in question, and for a common value of 1.0.

Comments

Estimates of σ_R for each super-area differ widely and at times (e.g. for A8+) lead to serious misfits to recent abundance indices. This is not surprising given the limited data available for each super-area. Hence the more robust approach of using a common value for all super-areas is preferred. The value put forward is 1.0, which is intermediate amongst the estimated value for each super-area and does not overly constrain recruitment estimates such as to result in a mis-fit to abundance indices, while still providing some estimation stabilisation for the more recent recruitment estimates.

For A7, the results for upweighting the recent trap CPUE series are preferred, given their consequent better fit to the most recent values of that index.

Reference

Johnston, S.J. and Butterworth, D.S. 2018. Projections of the west coast rock lobster resource under different poaching and future catch scenarios. MARAM/IWS/2018/WCRL/P4.

Table 1a: A8+ results. The values in parentheses next to the –lnL values are the associated σ values for that parameter.

	2018 assessment method (σ_R = 0.24)	2018 assessment method (σ_R = 0.24)	2019 assessment method σ_R fixed = **0.24**	2019 assessment method σ_R fixed = **1.00**
# estimable parameters	31	31	32	32
-lnL total (T=D+R)	-68.471	-68.471	-30.167	-65.103
-lnL from data (D)	-69.385	-69.385	-59.691	-68.080
R penalties (R)	0.914	0.914	29.52	2.977
Trap CPUE –lnL (σ)	-38.93 (0.180)	-38.93 (0.180)	-36.29 (0.202)	-41.12 (0.176)
Hoop CPUE –lnL (σ)	-38.18 (0.177)	-38.18 (0.177)	-39.06 (0.179)	-40.99 (0.168)
FIMS CPUE –lnL (σ)	-14.43 (0.341)	-14.43 (0.341)	-16.95 (0.316)	-15.82 (0.370)
R_2004	0.703	0.703	0.471	0.489
R_2007	0.790	0.790	0.513	0.625
R_2010	0.382	0.382	0.333	0.310
$\bar{x}$	(0.357)	**0.357** used for projections	0.310	0.450
Geometric mean 1975..2010	**0.316** used for projections	0.316	-	-
B75m(1996) (B75m(1996)/K)	10 590 (0.057)	10 590 (0.057)	13 329 (0.072)	10 126 (0.048)
B75m(2006) (B75m(2006)/K)	8 201 (0.044)	8 201 (0.044)	9 621 (0.052)	7 778 (0.037)
B75m(2018) (B75m(2018)/K)	5 589 (0.030)	5 589 (0.030)	4 384 (0.024)	4 162 (0.020)
B75m(2025)/B75m(2006)	0.873	1.332	0.621	1.053
B75m(2030)/B75m(2006)	0.757	1.952	0.631	1.435
	Om18n.for tue.res	Om18n.for am8.res	New83.res	New19.for New82.res

Table 1b: A7 results. The values in parentheses next to the –lnL values are the associated σ values for that parameter.

	2018 assessment method (σ_R = 1.97)	2018 assessment method (σ_R = 1.97)	2019 assessment method σ_R fixed = **1.97**	2019 assessment method σ_R fixed = **1.00**	2019 assessment method σ_R fixed = **1.00** **Trap CPUE WT*10**
# estimable parameters	26	26	27	27	27
-lnL total (T=D+R)	96.430	96.430	102.480	101.821	134.425
-lnL from data (D)	96.407	96.407	96.181	99.068	128.657
R penalties (R)	0.023	0.023	6.299	2.753	5.77
Trap CPUE –lnL (σ)	-5.164 (0.516)	-5.164 (0.516)	-7.100 (0.489)	-4.727 (0.526)	12.284 (0.669)
Hoop CPUE –lnL (σ)	-	-	-	-	-
FIMS CPUE –lnL (σ)	5.187 (0.752)	5.187 (0.752)	4.400 (0.723)	5.098 (0.724)	20.379 (0.850)
R_2004	0.034	0.034	0.078	0.018	0.009
R_2007	0.025	0.025	0.027	0.014	0.006
R_2010	0.044	0.044	0.035	0.026	0.019
$\bar{x}$	(0.069)	0.069 used for projections	0.044	0.048	0.029
Geometric mean 1975..2010	0.037 used for projections	(0.037)	-	-	-
B75m(1996) (B75m(1996)/K)	6964 (0.036)	6964 (0.036)	5738 (0.024)	6897 (0.023)	11131 (0.033)
B75m(2006) (B75m(2006)/K)	7613 (0.037)	7613 (0.037)	3675 (0.015)	4680 (0.016)	5363 (0.016)
B75m(2018) (B75m(2018)/K)	3586 (0.018)	4861 (0.023)	3072 (0.013)	3410 (0.012)	2520 (0.007)
B75m(2025)/B75m(2006)	0.612	0.907	1.387	1.360	0.820
B75m(2030)/B75m(2006)	1.044	1.714	1.770	1.802	1.074
	Bc71.res		New197.for New71.res	New72.res	New73.res

Table 1c: A56 results. The values in parentheses next to the –lnL values are the associated σ values for that parameter.

	2018 assessment method (σ_R = 0.55)	2018 assessment method (σ_R = 0.55)	2019 assessment method σ_R fixed = **0.55**	2019 assessment method σ_R fixed = **1.00**
# estimable parameters	31	31	32	32
-lnL total (T=D+R)	89.371	89.371	104.522	107.680
-lnL from data (D)	88.119	88.119	102.533	103.516
R penalties (R)	1.252	1.252	1.989	4.165
Trap CPUE –lnL (σ)	-1.897 (0.150)	-1.897 (0.150)	-1.897 (0.150)	-1.897 (0.150)
Hoop CPUE –lnL (σ)	-21.042 (0.270)	-21.042 (0.270)	-18.888 (0.310)	-18.233 (0.309)
FIMS CPUE –lnL (σ)	14.328 (1.101)	14.328 (1.101)	14.667 (1.091)	14.437 (1.081)
R_2004	0.046	0.046	0.038	0.044
R_2007	0.049	0.049	0.041	0.047
R_2010	0.077	0.077	0.060	0.052
$\bar{x}$	(0.049)	0.049 used for projections	0.047	0.047
Geometric mean 1975..2010	0.041 used for projections	NA	-	-
B75m(1996) (B75m(1996)/K)	1048 (0.004)	1048 (0.004)	1020 (0.004)	1121 (0.004)
B75m(2006) (B75m(2006)/K)	1728 (0.007)	1728 (0.007)	1705 (0.007)	1932 (0.008)
B75m(2018) (B75m(2018)/K)	3261 (0.013)	3261 (0.013)	2572 (0.010)	3016 (0.012)
B75m(2025)/B75m(2006)	2.288	2.825	2.227	2.108
B75m(2030)/B75m(2006)	2.233	3.187	2.690	2.481
	Bc561.res	D5.res	New19.for New561.res	New562.res

Table 1d: A34 results. The values in parentheses next to the –lnL values are the associated σ values for that parameter.

	2018 assessment method (σ_R = 1.318)	2018 assessment method (σ_R = 1.318)	2019 assessment method σ_R fixed = **1.32**	2019 assessment method σ_R fixed = **1.00**
# estimable parameters	31	31	32	32
-lnL total (T=D+R)	120.714	120.714	140.925	144.813
-lnL from data (D)	120.568	120.568	139.002	141.937
R penalties (R)	0.146	0.146	1.923	2.876
Trap CPUE –lnL (σ)	-5.154 (0.494)	-5.154 (0.494)	-6.283 (0.476)	-5.823 (0.484)
Hoop CPUE –lnL (σ)	-4.089 (0.533)	-4.089 (0.533)	-3.352 (0.458)	-4.189 (0.534)
FIMS CPUE –lnL (σ)	22.061 (1.521)	22.061 (1.521)	22.830 (1.512)	22.700 (1.504)
R_2004	0.076	0.076	0.057	0.063
R_2007	0.092	0.092	0.082	0.076
R_2010	0.102	0.102	0.088	0.088
$\bar{x}$	(0.0862)	0.0862 used for projections	0.104	0.071
Geometric mean 1975..2010	0.0589 used for projections	(0.0589)	-	-
B75m(1996) (B75m(1996)/K)	2711 (0.016)	2711 (0.016)	2965 (0.017)	36631 (0.021)
B75m(2006) (B75m(2006)/K)	4519 (0.027)	4519 (0.027)	4932 (0.028)	4877 (0.028)
B75m(2018) (B75m(2018)/K)	3346 (0.020)	3346 (0.020)	3166 (0.018)	3278 (0.019)
B75m(2025)/B75m(2006)	0.701	1.033	0.872	0.808
B75m(2030)/B75m(2006)	0.599	1.201	1.148	0.920
	Bc341.res	K5.res	New19.for New341.res	New342.res

Table 1e: A12 results. The values in parentheses next to the –lnL values are the associated σ values for that parameter.

	2018 assessment method (σ_R = 2.55)	2018 assessment method (σ_R = 2.55)	2019 assessment method σ_R fixed = **2.55**	2019 assessment method σ_R fixed = **1.00**
# estimable parameters	20	20	32	32
-lnL total (T=D+R)	-33.771	-33.771	-29.820	-29.981
-lnL from data (D)	-33.936	-33.936	-34.356	-32.237
R penalties (R)	0.165	0.165	5.536	2.256
Trap CPUE –lnL (σ)	-	-	-	-
Hoop CPUE –lnL (σ)	-45.730 (0.204)	-45.730 (0.204)	-45.624 (0.210)	-42.424 (0.226)
FIMS CPUE –lnL (σ)	-	-	-	-
R_2004	0.003	0.003	0.003	0.006
R_2007	0.032	0.032	0.030	0.006
R_2010	0.022	0.022	0.059	0.024
$\bar{x}$	(0.022)	0.022 used for projections	0.025	0.014
Geometric mean 1975..2010	0.021 used for projections	(0.021)	-	-
B75m(1996) (B75m(1996)/K)	1897 (0.025)	1897 (0.025)	618 (0.011)	652 (0.006)
B75m(2006) (B75m(2006)/K)	1783 (0.023)	1783 (0.023)	924 (0.016)	907 (0.009)
B75m(2018) (B75m(2018)/K)	1618 (0.021)	1621 (0.021)	1182 (0.020)	1037 (0.010)
B75m(2025)/B75m(2006)	0.804	0.928	2.570	3.931
B75m(2030)/B75m(2006)	0.789	1.115	2.445	3.587
	Bc121.res	Z5.res	New1912.for New121.res	New122.res

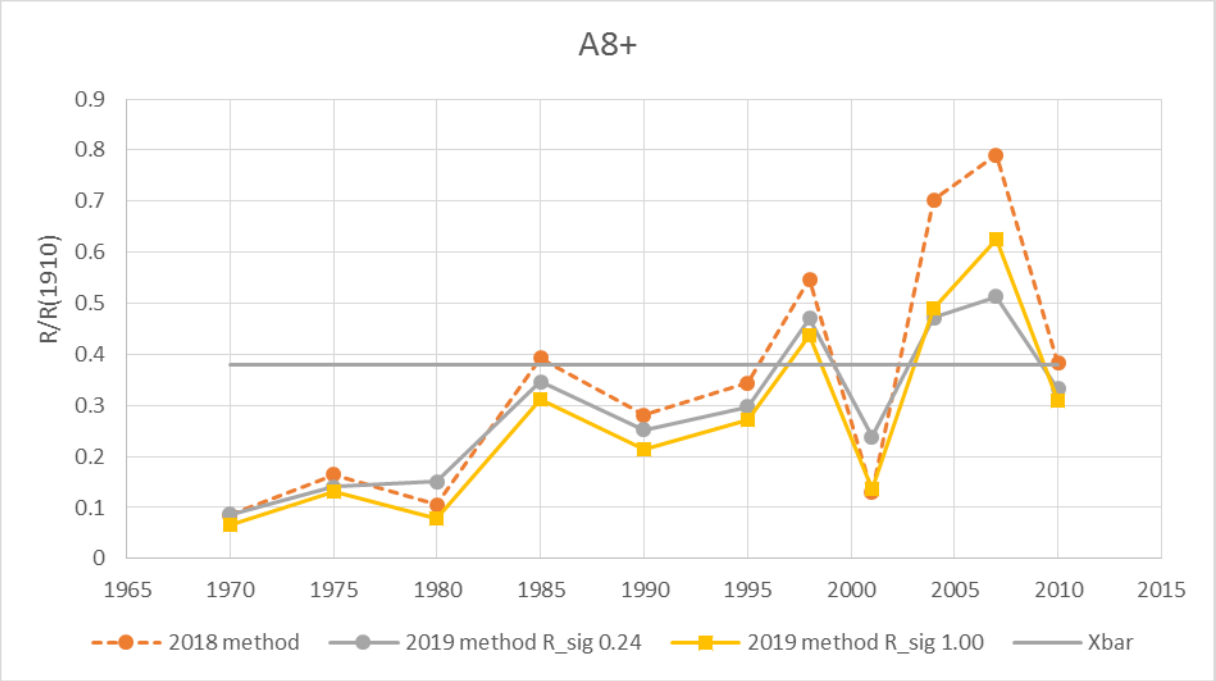


Figure 1a: R estimates for A8+ from the 2018 assessment method, and the 2019 assessment method with σ_R=**0.24** and **1.00.**

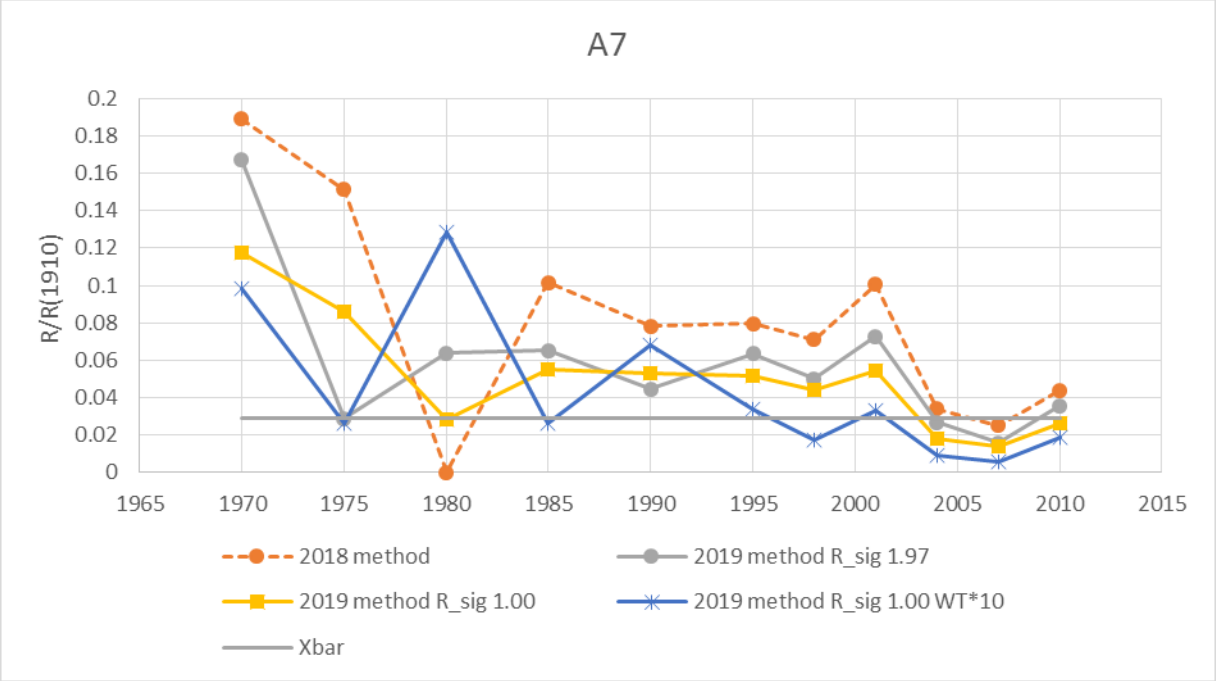


Figure 1b: R estimates for A7 from the 2018 assessment method, and the 2019 assessment method with σ_R=**1.97** and **1.00.**

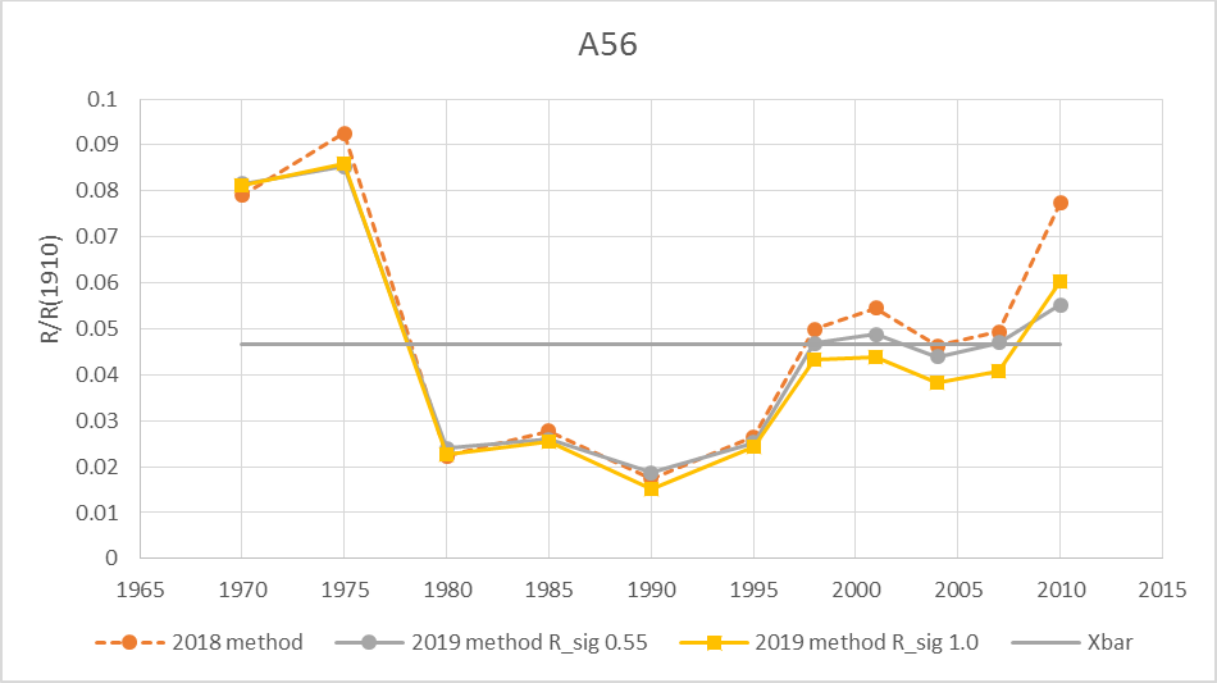


Figure 1c: R estimates for A56 from the 2018 assessment method, and the 2019 assessment method with σ_R=**0.55** and **1.00.**

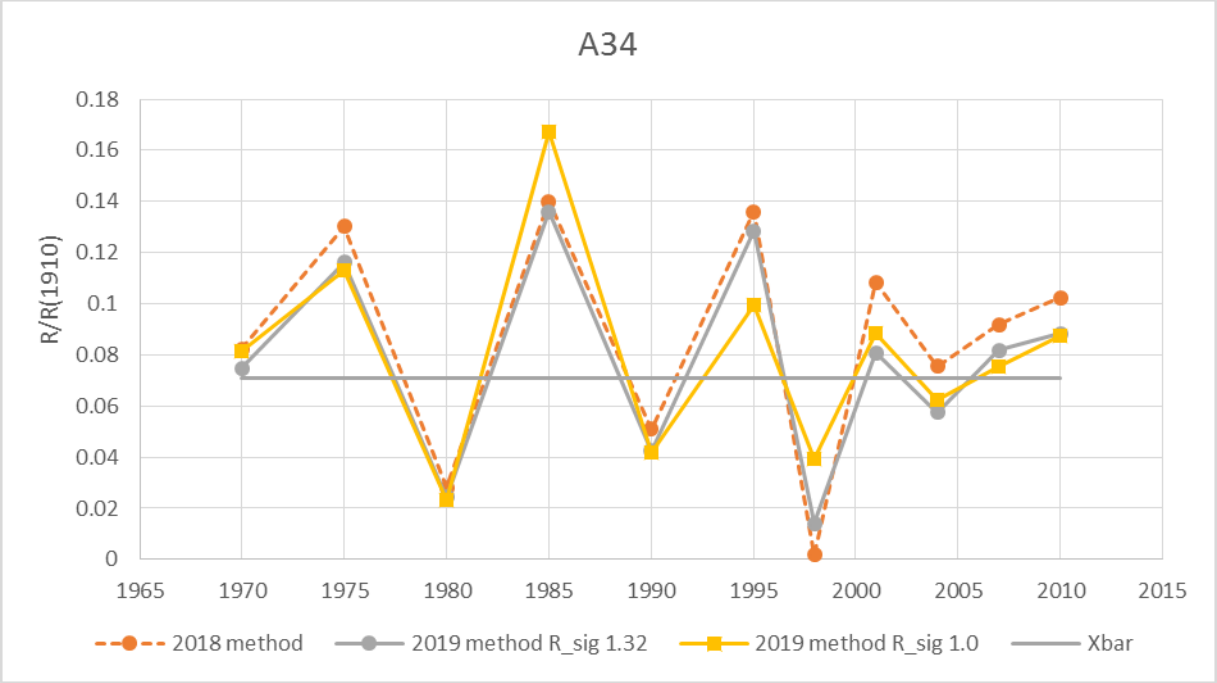


Figure 1d: R estimates for A34 from the 2018 assessment method, and the 2019 assessment method with σ_R=**1.32** and **1.00.**

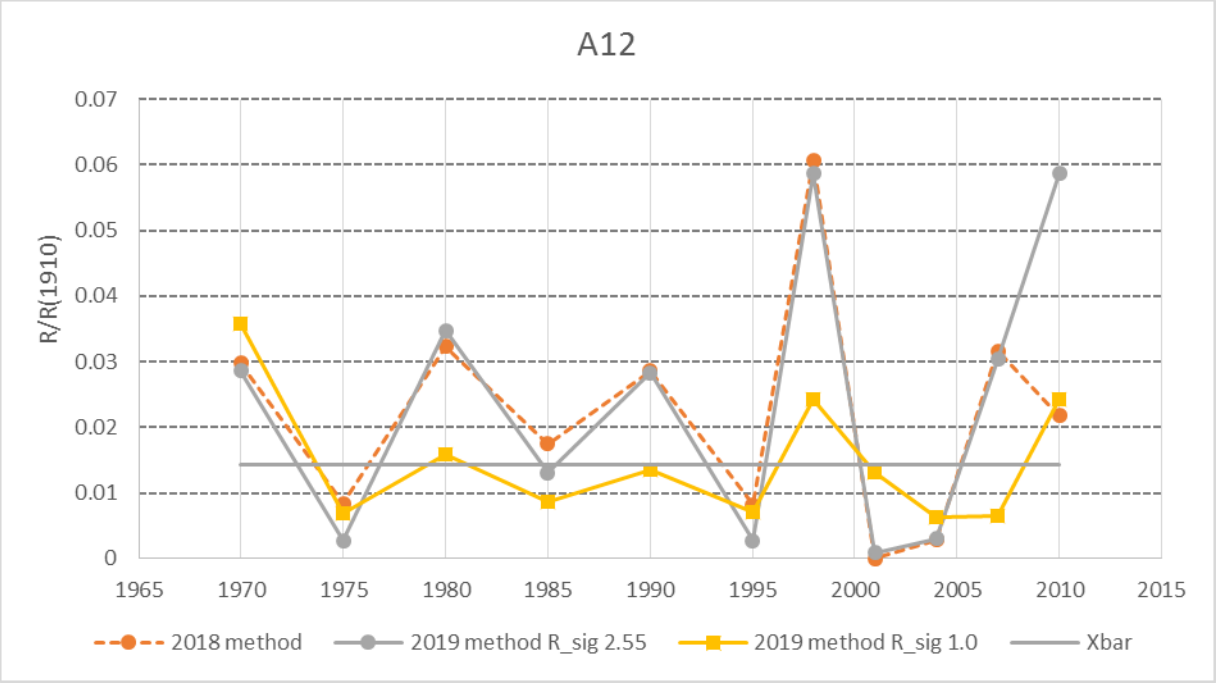


Figure 1e: R estimates for A12 from the 2018 assessment method, and the 2019 assessment method with σ_R=**2.55** and **1.00.**

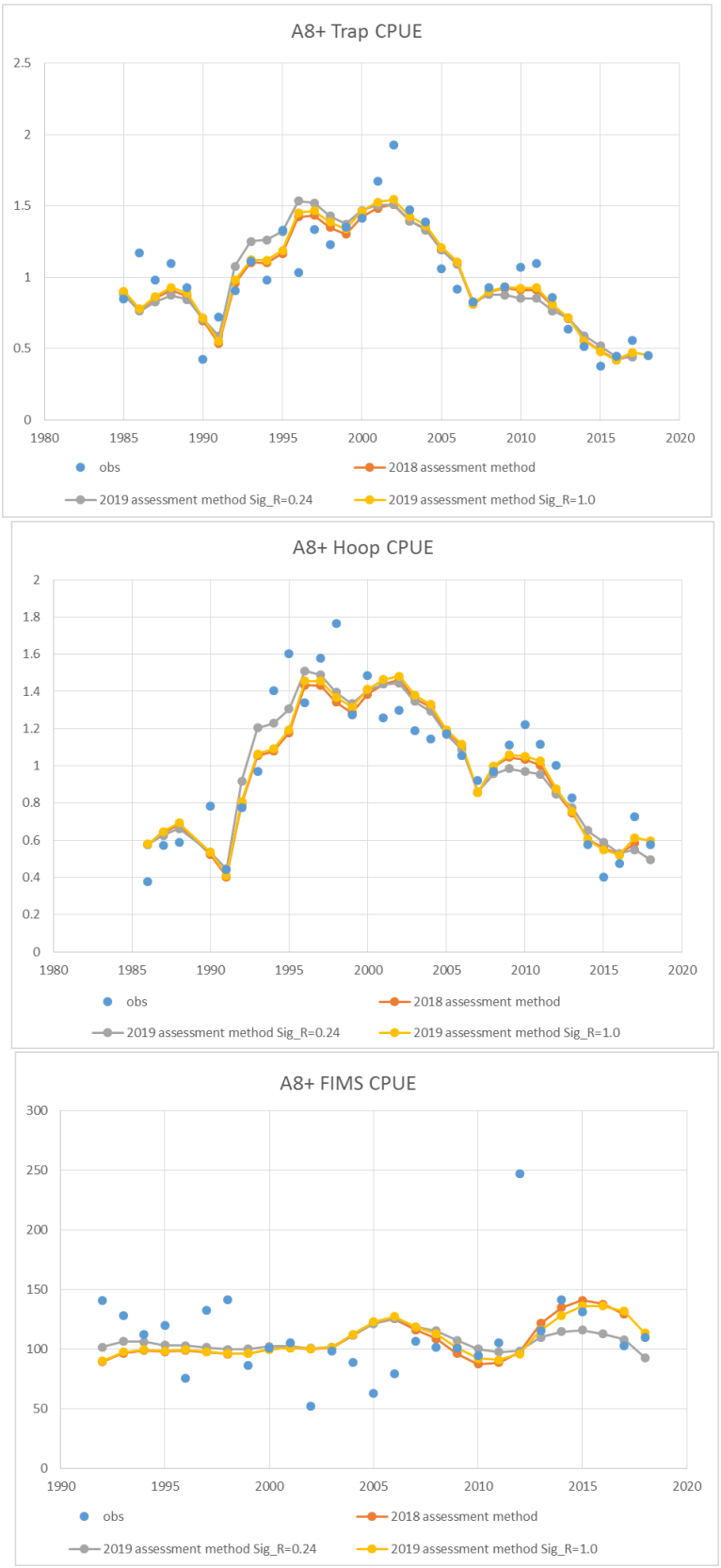


Figure 2a: Comparison of fits to A8+ CPUE for the different assessment methods – note that the 2018 method is applied to one less year of data than the 2019 method.

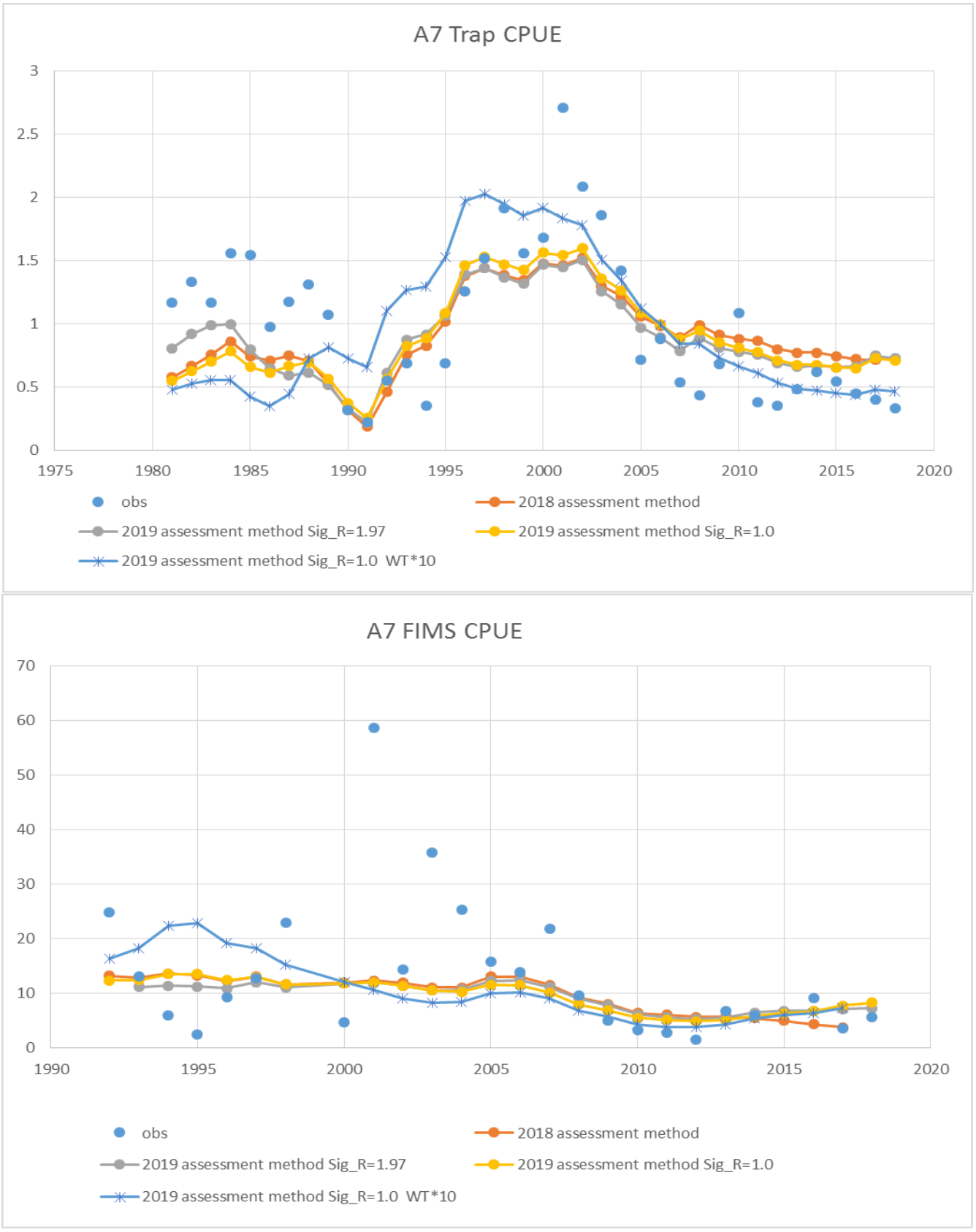
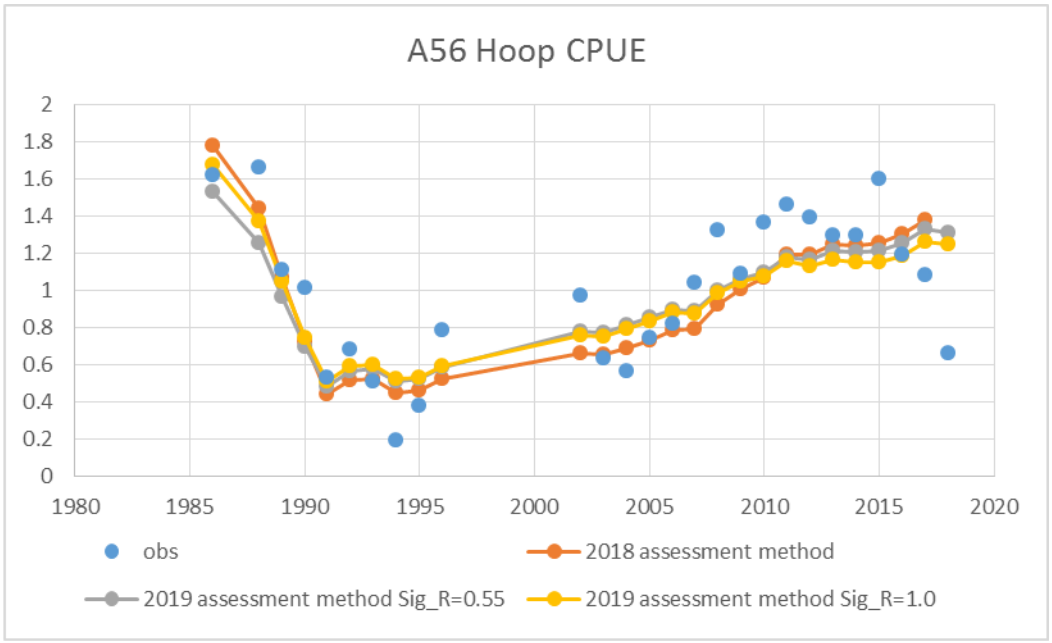


Figure 2b: Comparison of fits to A7 CPUE for the different assessment methods. Note that the 2018 method is applied to one less year of data than the 2019 method.



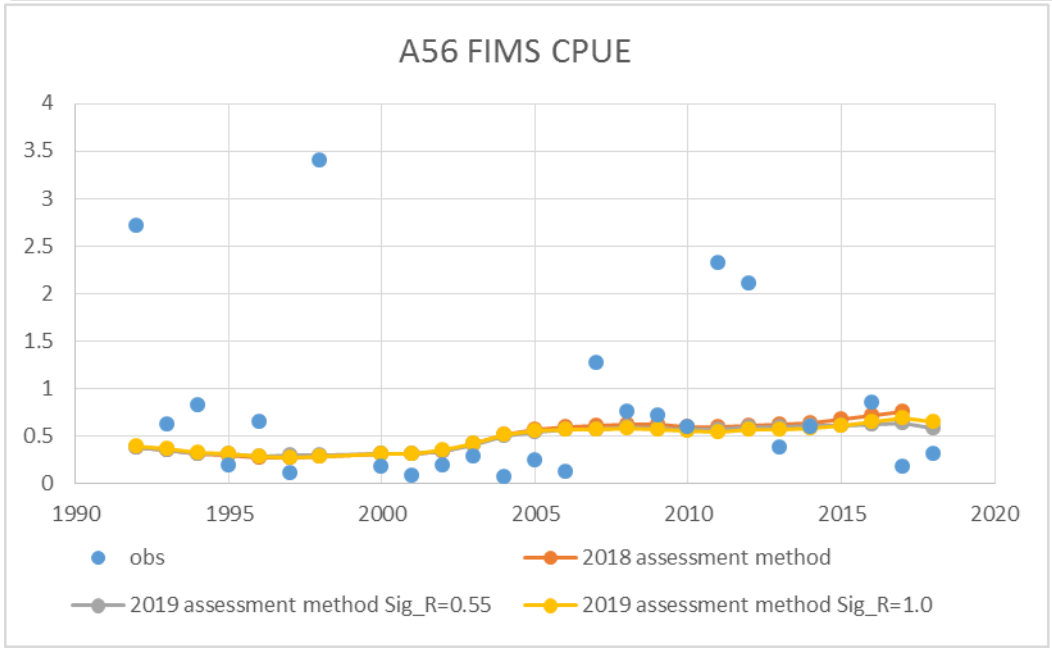
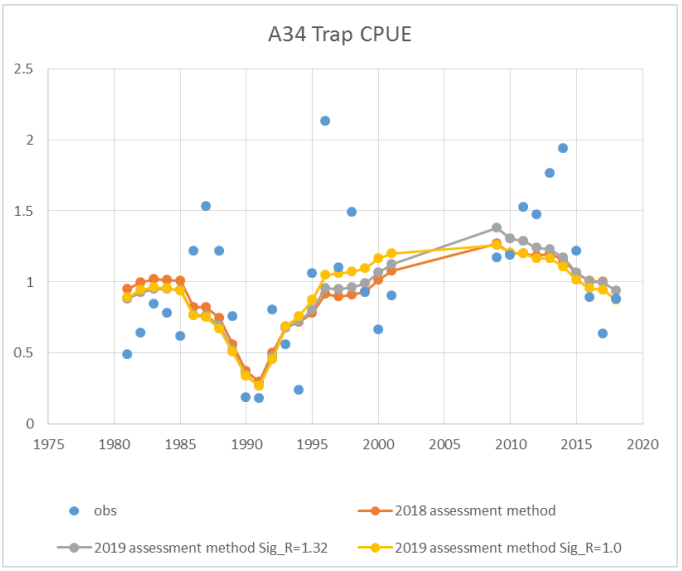
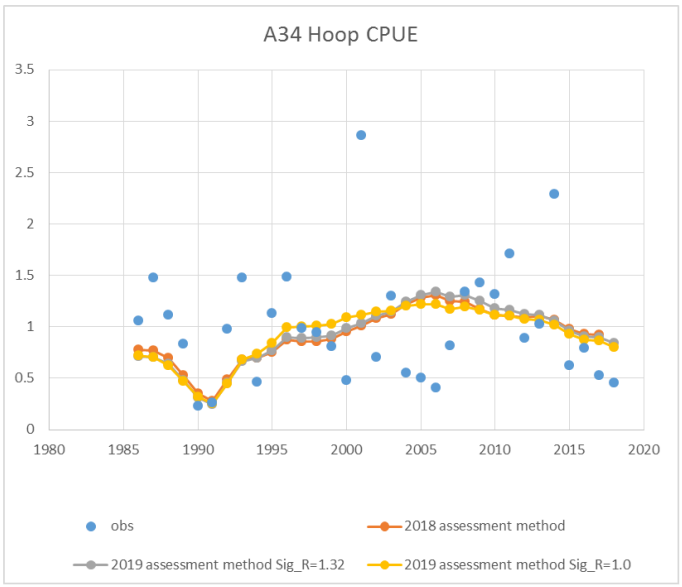


Figure 2c: Comparison of fits to A56 CPUE for the different assessment methods. Note that the 2018 method is applied to one less year of data than the 2019 method.





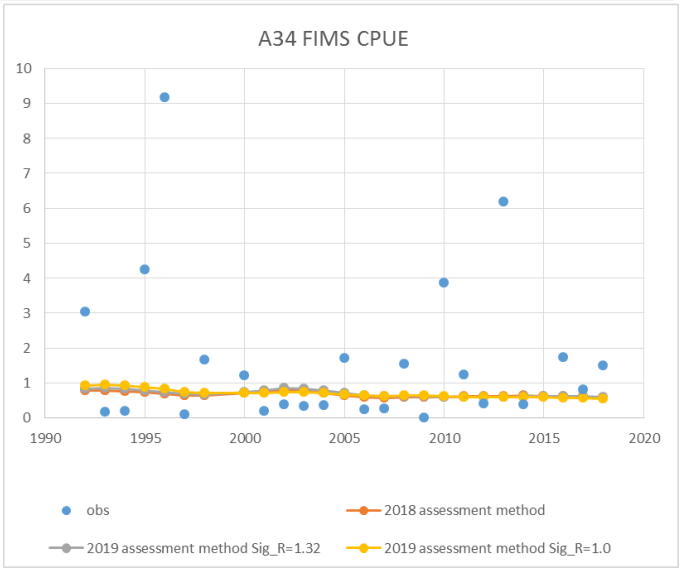


Figure 2d: Comparison of fits to A34 CPUE for the different assessment methods. Note that the 2018 method is applied to one less year of data than the 2019 method.

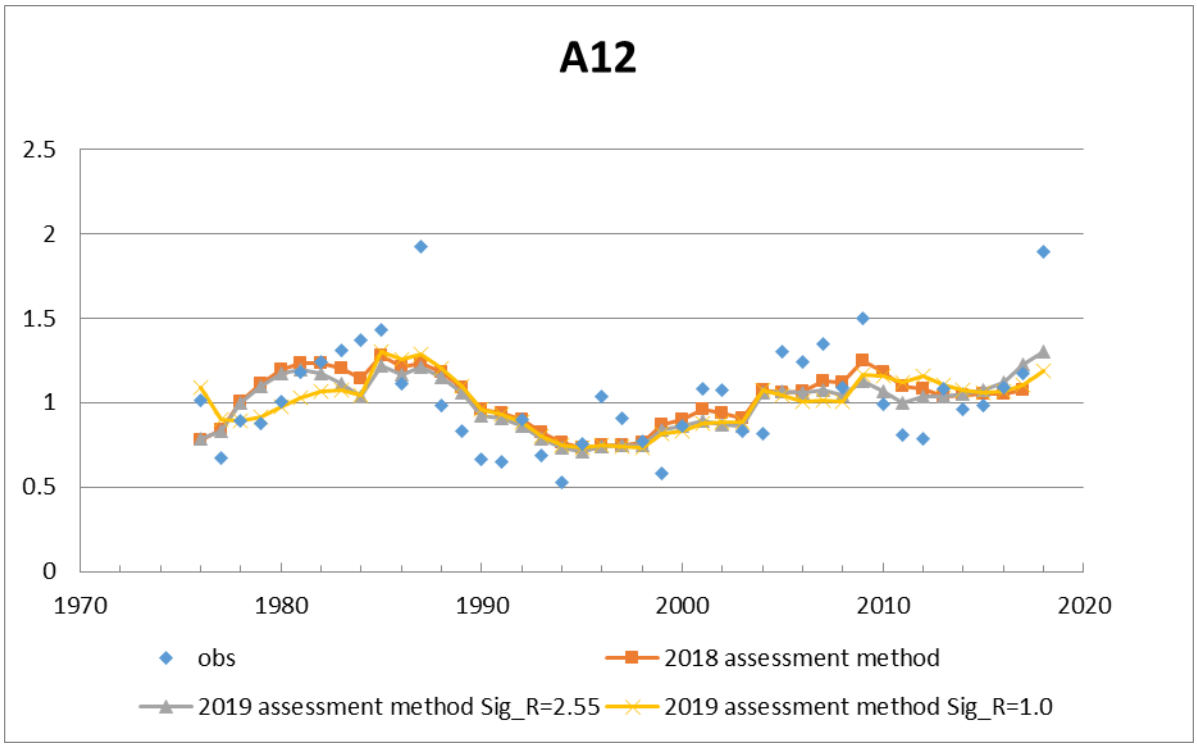


Figure 2e: Comparison of fits to A12 CPUE for the different assessment methods. Note that the 2018 method is applied to one less year of data than the 2019 method.

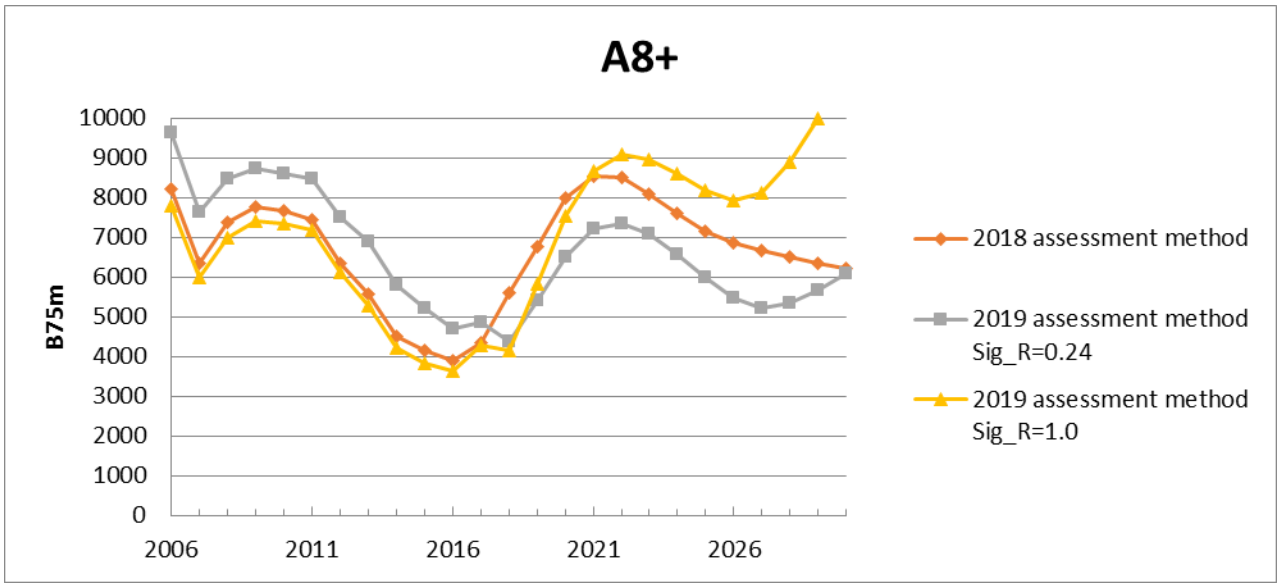


Figure 3a: Comparison between the A8+ B75m trajectories (for 2006-2030) of the different methodologies. Note that the 2018 method is applied to one less year of data than the 2019 method.

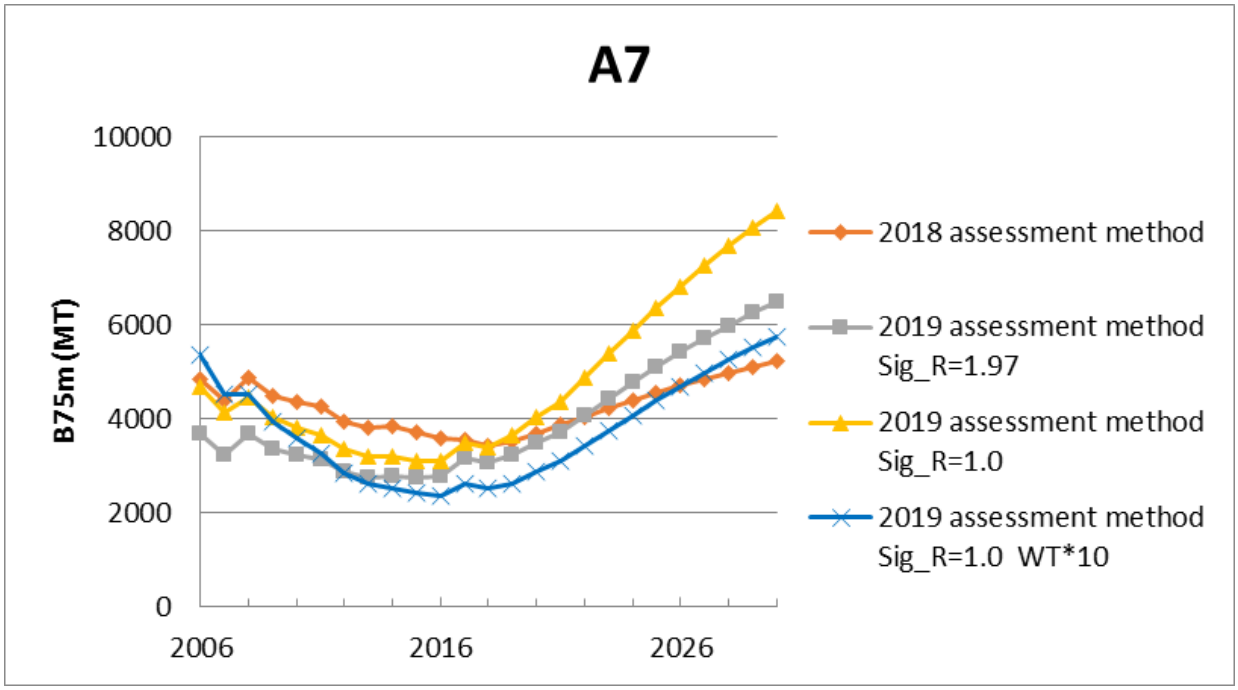


Figure 3b: Comparison between the A7 B75m trajectories (for 2006-2030) of the different methodologies. Note that the 2018 method is applied to one less year of data than the 2019 method.

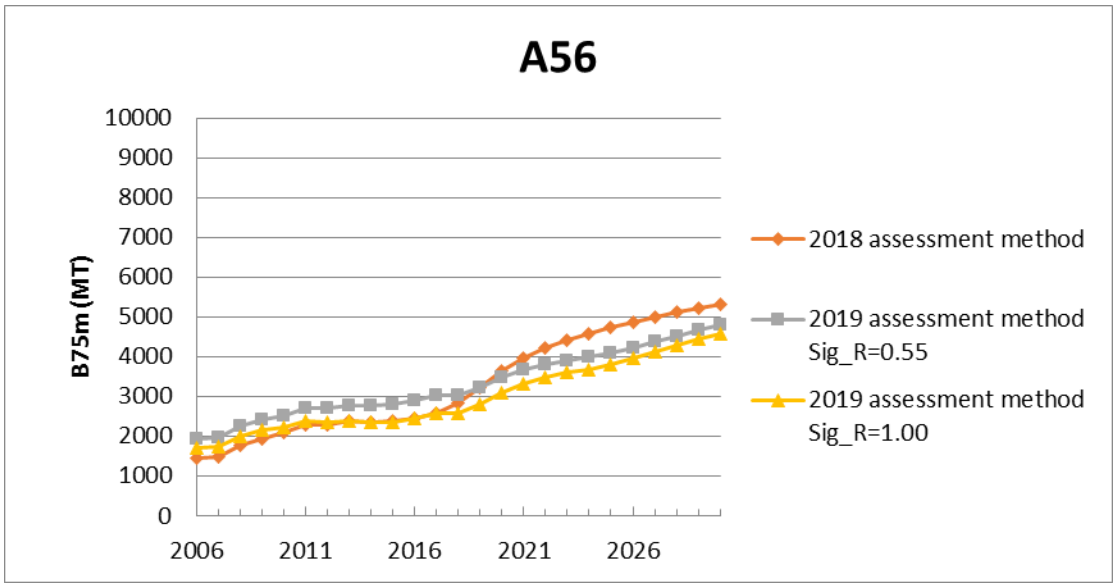


Figure 3c: Comparison between the A56 B75m trajectories (for 2006-2030) of the different methodologies. Note that the 2018 method is applied to one less year of data than the 2019 method.

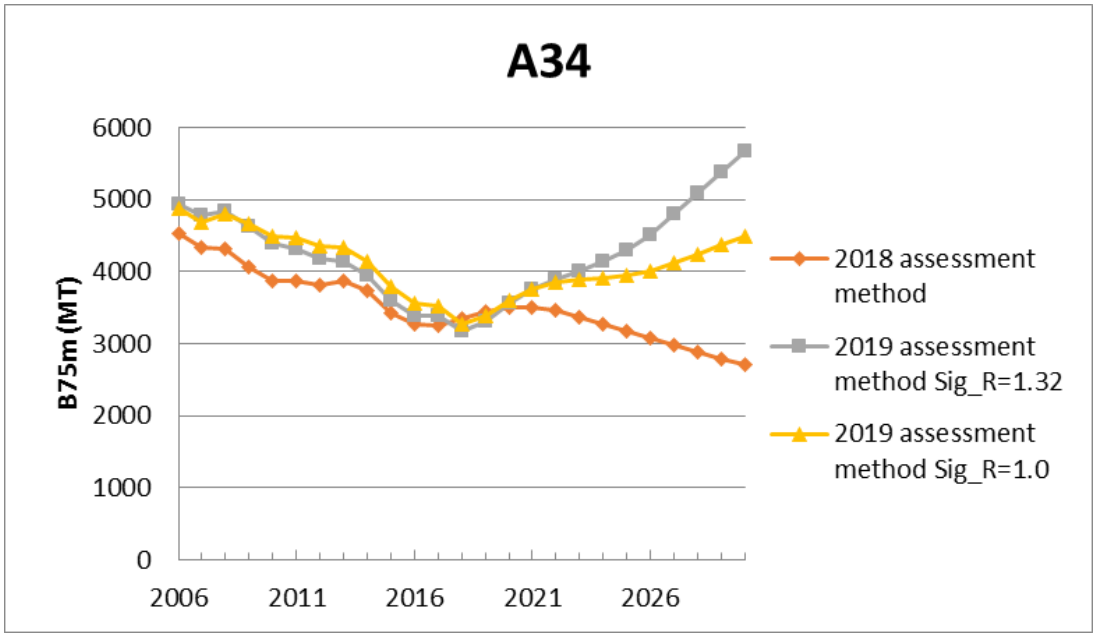


Figure 3d: Comparison between the A34 B75m trajectories (for 2006-2030) of the different methodologies. Note that the 2018 method is applied to one less year of data than the 2019 method.

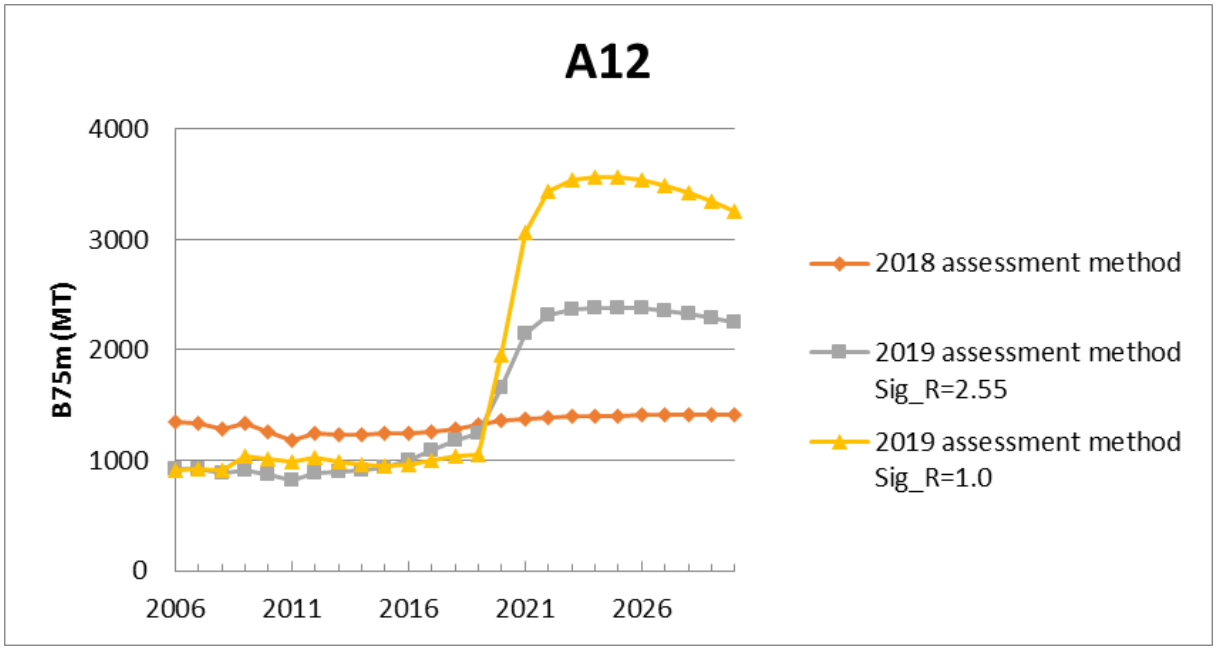


Figure 3e: Comparison between the A12 B75m trajectories (for 2006-2030) of the different methodologies. Note that the 2018 method is applied to one less year of data than the 2019 method.